# ANALYTIC DECISION

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PROMPT and proper decision is the mark of a master mind. In common with all other mental traits, this ability is given in large measure to some men, while others develop it only by painstaking effort.

There always has been great opportunity in the vast industrial activities of the United States for the man naturally gifted along this line. But it is only comparatively recently that attention has been focused on the need for its general cultivation. The great natural resources of our country and our one-time isolation form the underlying reason for this condition. The penalty for only partial success has been far less severe with us than in countries where the margin between resources and necessity has been narrow.

Today, however, there is a growing realization that our remaining resources must be conserved. This fact is further driven home by the looming of foreign competition on the horizon, both in export and domestic endeavor. Our enterprises must be constructed, launched, and navigated on fundamentally sound principles. We must nationally outgrow our complacent toleration of headlong plunging to ultimate success through wasteful failures. We must nail our colors to the mast of initial success, and nothing less must be permitted to satisfy. "If at first you don't succeed, try, try again," is a will-o'-the-wisp and must be replaced by the beacon, "SUCCEED THE FIRST TIME."

Correct decision is based upon knowledge of underlying facts and an orderly marshaling and weighing of these facts. This can be expressed in the single word "Analysis." The lay mind balks at that word, presenting a picture of pages of intricate mathematical calculations that form a closed book to all but the technically elect. Now, mathematical analysis tempered with common sense is of vital importance, and our need for it is great, but it is only one method for the orderly presentation of facts. Analysis is too valuable a tool to be restricted to the use of the few men who can claim the rare combination of a trained mathematical mind, with the ability to apply this gift practically. Analysis, conscious or unconscious, mental or written, is the only sure road to a correct decision.

At the meeting in December, 1921, of the American Society of Mechanical Engineers and the Society for the promotion of Engineering Education, Prof. C. A. Adams said that what was wanted in every engineer and every student was the habit of honest thought, the habit of demanding a sound foundation for his analysis in whatever field he is and of building soundly on that foundation, and not the habit of thinking he knows something and throwing from his memory the things which he ought to know. This is typical of the comment of many of our leading men today.

It is the purpose of this paper to follow up the broad general thought thus expressed, with an outline of certain practical methods for training the mind in analytic thinking, and to give a few reasons why their cultivation is worth while. While the illustrations and discussion that follow are confined to the field of engineering, the fundamental principles and methods outlined are of universal application, although, as pointed out in some detail later, the final answer is not always immediately forthcoming.

In general, the technical graduate has no clearly defined method for the preparation of a written analysis. His production, if he reduces his ideas to writing at all, is apt to be a more or less logical argument.

The ideal written analysis consists first of a cold presentation of all the salient facts listed in some logical order, couched in the smallest possible number of words, and ungarnished with argument. This, in a complete state, insures a broad and clear grasp of the problem and eliminates the danger of overlooking more or less vital factors.

This is logically followed by a detail discussion or argument on each point, the first presentation constituting an index for the second, and the second being the scales for weighing the first.

There are several phases demanding independent listing and weighing. The first consideration should be given to the desired results. What are we trying to accomplish? This falls very conveniently into the form of four lists:

*a.* Results that must be secured.
*b.* Results desired but subject to compromise.
*c.* Results undesirable but subject to compromise.
*d.* Results that must be avoided.

The proper length of this paper prohibits a complete discussion of this phase in a specific problem. The general thought may be illustrated by one ideal in each class in the development of a method for heat treating steel, as follows:

*a.* Brinnel hardness above a certain fixed minimum.
*b.* Reduction of area as high as possible.
*c.* Warping reduced to a minimum.
*d.* Incipient cracks.

Heat treatment is surrounded with a very long and complicated set of positive and negative ideals and those noted are, as stated, only indicative.

After securing a clear grasp of the problem, we enter the phase of creating schemes for satisfying the ideals. In our large industrial organizations, there are usually a number of men who work in parallel on the major undertakings. Inevitably, and also fortunately, competitive schemes are advanced as offering the best solution. Which scheme should be adopted—the best scheme or that backed by the best salesmanship? The former, of course, but how shall the decision be reached?

There exists in the human mind the same blind faith in its mental children that we see every day in the human heart for its physical offspring. The imagination capable of creating a new scheme goes hand in hand with enthusiasm for that particular scheme. Thus, when a problem has been long enough in the limelight to foster the growth of various schools of thought, it frequently becomes involved in an apparently hopeless tangle of discussion and argument. The advocate of each candidate for election has focused his attention so closely on the glittering advantages of the scheme he sponsors that his eyes are blinded to its obvious defects. Conversely, the shortcomings of competitive schemes so cloud his vision that he can see no ray of light from their real advantages.

Then is the time to enter the phase of written eliminative analysis. The first step is a collection of all the schemes worthy of serious consideration. Dependent on the nature of the case, each scheme should be represented in one of the following ways:

*a.* A thumbnail sketch.
*b.* A tabloid description.
*c.* A longer word outline and a reference number.

These are listed in the order of preference, the ideal being to make the chart described below as brief and as self-contained as possible.

The next step is of vital importance, and consists of the determination of the viewpoints from which the various schemes must be judged.

In thus analyzing structures, the logical order is that of manufacture and use—in general, as follows:

State of the art, and patent situation, if involved.
Raw material.
Machine tools and operations.
Cost and time to fabricate.
Applicability to the whole, if analyzing a part.
Transportation problems, if involved.
Adaptability to service.
Life expectation.
Maintenance.

The fundamental viewpoints fall into several relative classes, and in some cases, one individual class.

First—Questions that lend themselves to "Yes" and "No" answers. The questions are so drawn that the answer "Yes" is in favor of the scheme and "No" is against the scheme. This is done to avoid confusion when reviewing the columns to determine the final course of action. As much of the analysis as possible is worked out in this form.

When "Yes" and "No" cannot be conveniently employed, the next preferred class is a relative percentage rating, with the headings drawn in a way that makes a high percentage favorable to the scheme, the best being rated 100%.

Relative desirability, which is insufficiently determinate for an intelligent percentage rating, falls in the third or alphabetical class. In this class the various schemes are placed in the order of desirability from the particular fundamental viewpoint under consideration, "A" being most desirable, and descending alphabetically.

The lapse of time involved forms another relative class, a long time being an obvious disadvantage in manufacturing operations.

These more or less definitely relative classes are followed in some cases by a miscellaneous class which brings out important individual characteristics. The schemes are arranged as top headings for columns, with Roman Numeral designation, while the fundamental viewpoints form side headings for lines with Arabic numeral reference numbers. This is for ready reference in correspondence.

The proper frame of mind while filling out the chart is an absolute essential for its successful application. The analysis is ruined if undertaken to prove a pet scheme. It must be a coldly honest search for fundamental facts. When deciding what to enter in a given space the mind must be closed to all other considerations and that one space must be weighed absolutely on its own merits. This fundamental requirement emphasizes the fact that this analysis has a clear limitation and falls far short of being a universal clearing house for moot questions.

When the aggregation of known fact is insufficient for firm decision, this method of analysis fails to give the answer. It will, however, do one of two things; namely, lead to a decision, or uncover the lack of sufficient fact for a decision and show where development of new facts is essential.

This method of analysis is in a measure self-eliminative with any individual who starts its use. It trains his mind to cold judicial thinking and increases his ability to perform reliable mental analysis.

But after once securing results out of a complicated situation with this method, it becomes second nature to revert to the chart study when pure mental analysis fails to bring conviction that a given line of action should be followed. It also frequently happens that the crystallization of schemes and requirements in a polished chart will lead almost automatically to a new scheme which is better than its predecessors.

This method is essentially negative and therefore must be defended by logical reasoning before it can hope to compete with positive analysis. In other words, we are proposing to successively eliminate the least desirable plans or schemes, thus automatically leaving the best in undisputed possession of the field, instead of at once selecting the best.

Is there logical defense for this? As a general proposition, the positive course of action is productive of the advance of any art, while the negative contributes little or nothing. The fundamental reason for eliminative analysis lies in the fact that no machine or plan is perfect and therefore the field may be most ably narrowed down to the best course of action by the successive elimination of the undesirables, thus determining the least imperfect. A positive or constructive stage is passed through in the conception of the various schemes to be analyzed.

We find an analogy for the two kinds of analysis in the locomotive whose gears were used to illustrate the method. The propelling motors form the positive element, while the air-brakes constitute the negative. A brake application is the best thing that can happen to many schemes.

Following our analogy further, it is frequently found that the best scheme falls too far short of the ideal, and our train of thought must accelerate again and run to some more or less remote station to deliver the goods. Thus we find cooperation rather than competition of analytic methods.

The attitude of men toward this type of written anaylsis has formed a very interesting study in psychology. It is quite usual to meet with considerable mental inertia when the preparation of a formal study of this kind is suggested. The young engineer in particular feels that he knows all the points involved after he has reviewed the situation and that the written record is a complete waste of time, and in many cases this may be true. The fact remains, however, that when important practices are to be established, it is wise to prepare a clean-cut record of the reasons underlying the decision. Then, as the art is developed by successive construction, the basic analysis can be checked and any existing weaknesses corrected.

Furthermore, when quick decisions are demanded by circumstances, a collection of carefully worked out analyses on related subjects is invaluable for bringing to light the fundamentals that must be weighed.

Having arrived at a decision as to the best of the proposed schemes, our analysis is still incomplete. As has been previously stated, none of the schemes may be adequate. The tentatively accepted scheme must now be scrutinized.

Usually this review can be handled by making parallel lists of the advantages and disadvantages followed, as before, by a discussion of the disadvantages, and a decision must be made as to whether or not each can be tolerated in view of the advantages gained.

In complicated structures, it is further essential to list:

*a.* The possibility of misfunctioning, or failure of each part.

*b.* The results of such events.